US009105431B2

(12) **United States Patent**
Sora

(10) **Patent No.:** **US 9,105,431 B2**
(45) **Date of Patent:** **Aug. 11, 2015**

(54) **ELECTROMAGNETIC RELAY**

(75) Inventor: **Yosuke Sora**, Yokohama (JP)

(73) Assignee: **NISSAN MOTOR CO., LTD.**, Yokohama-shi, Kanagawa (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/124,493**

(22) PCT Filed: **Mar. 8, 2012**

(86) PCT No.: **PCT/JP2012/056027**
§ 371 (c)(1),
(2), (4) Date: **Dec. 6, 2013**

(87) PCT Pub. No.: **WO2012/176505**
PCT Pub. Date: **Dec. 27, 2012**

(65) **Prior Publication Data**

US 2014/0092517 A1 Apr. 3, 2014

(30) **Foreign Application Priority Data**

Jun. 20, 2011 (JP) 2011-136151

(51) **Int. Cl.**

H01H 9/00	(2006.01)
H01H 50/44	(2006.01)
H01H 3/60	(2006.01)
H01H 47/04	(2006.01)
H01H 50/16	(2006.01)
H01H 47/22	(2006.01)

(52) **U.S. Cl.**
CPC ***H01H 50/44*** (2013.01); ***H01H 3/60*** (2013.01); ***H01H 47/04*** (2013.01); *H01H 47/22* (2013.01); *H01H 50/16* (2013.01)

(58) **Field of Classification Search**
USPC 361/139, 144, 160
See application file for complete search history.

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Primary Examiner — Danny Nguyen
(74) *Attorney, Agent, or Firm* — Young Basile

(57) **ABSTRACT**

The present invention is provided with a fixed contact, a movable contact which selectively contacts with or separates from the fixed contact and a drive means which has at least an electromagnetic coil and drives the movable contact so that the movable contact comes into contact with the fixed contact. The drive means generates a first driving force for bringing the movable contact into contact with the fixed contact, and a second driving force larger than the first driving force for maintaining the contact state between the movable contact and the fixed contact.

5 Claims, 6 Drawing Sheets

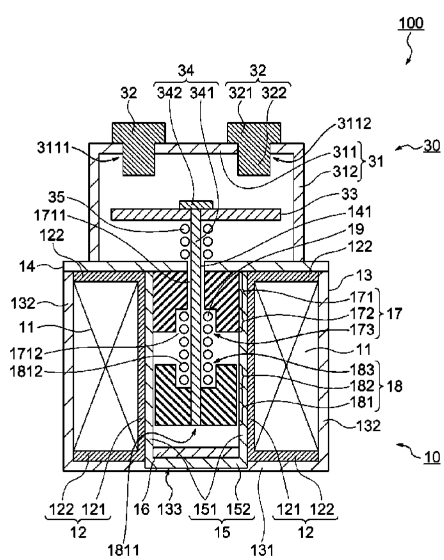

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FIG. 1

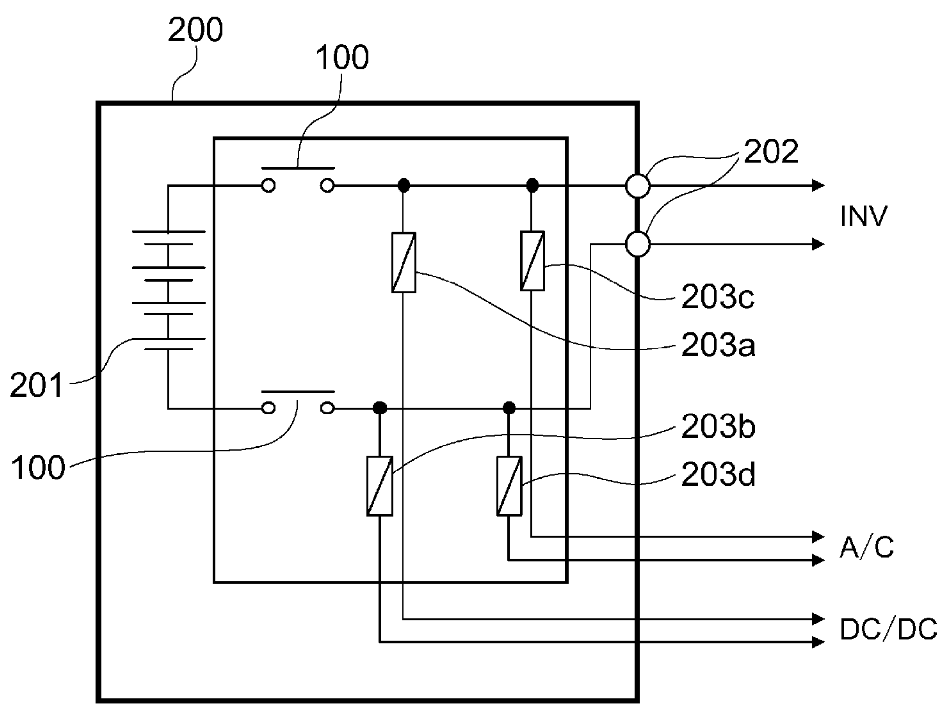

FIG. 2

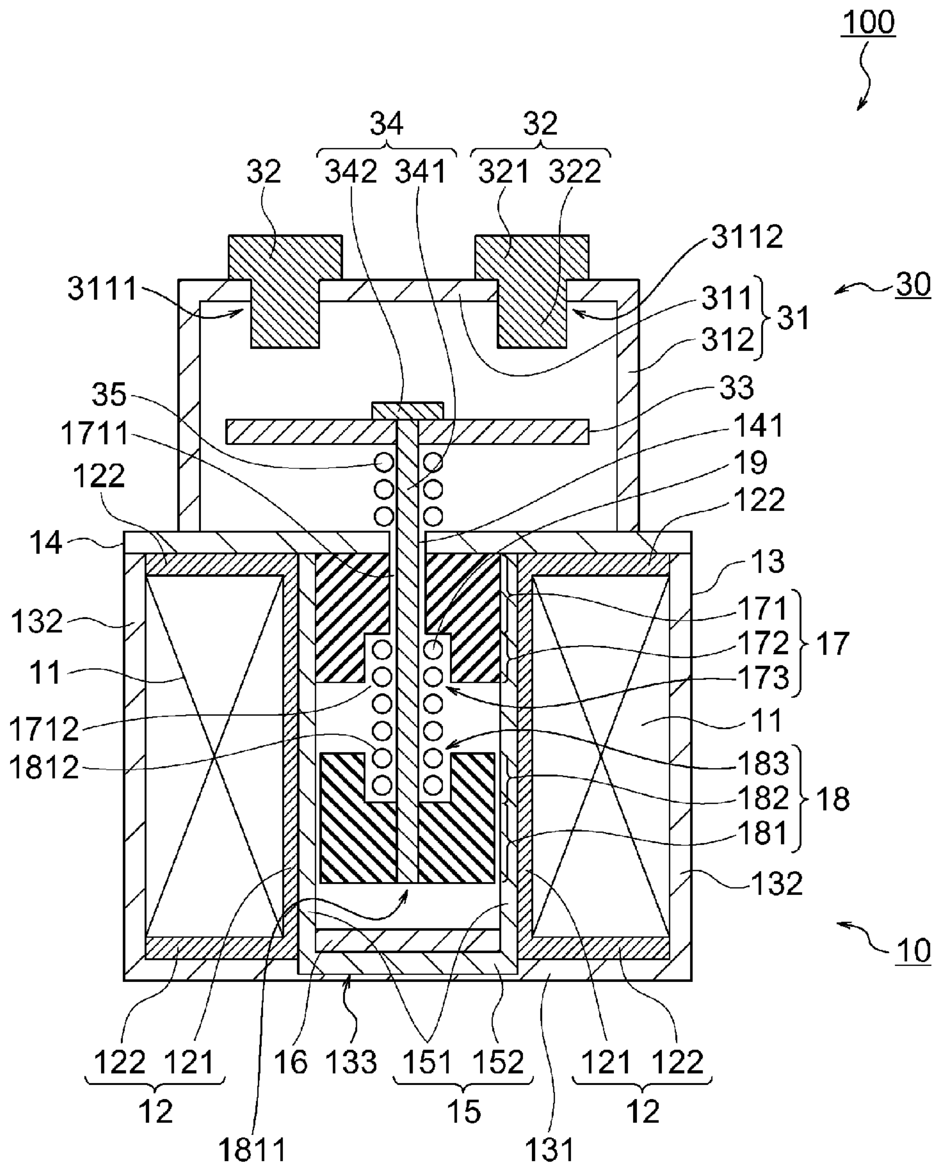
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FIG. 3

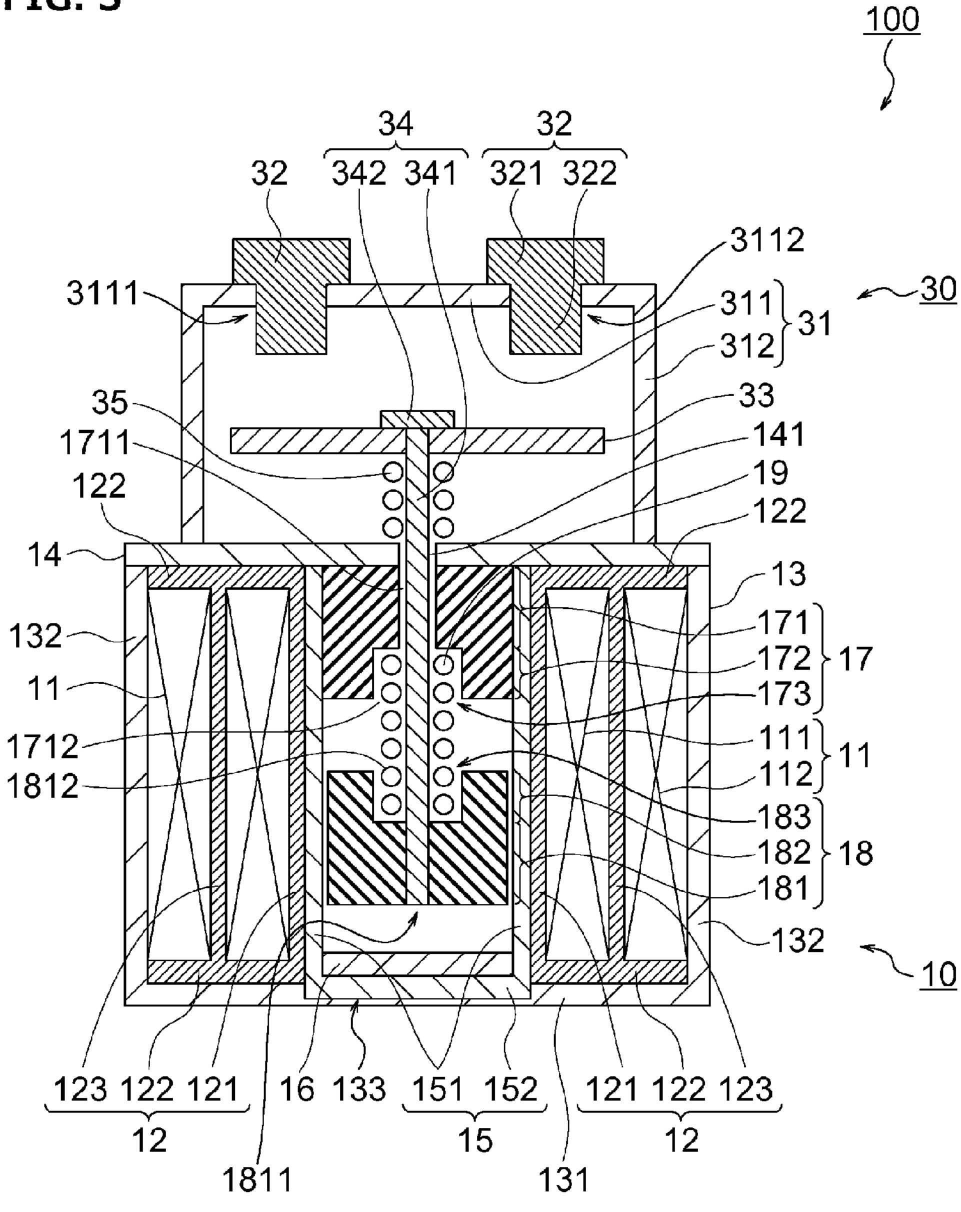
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FIG. 4

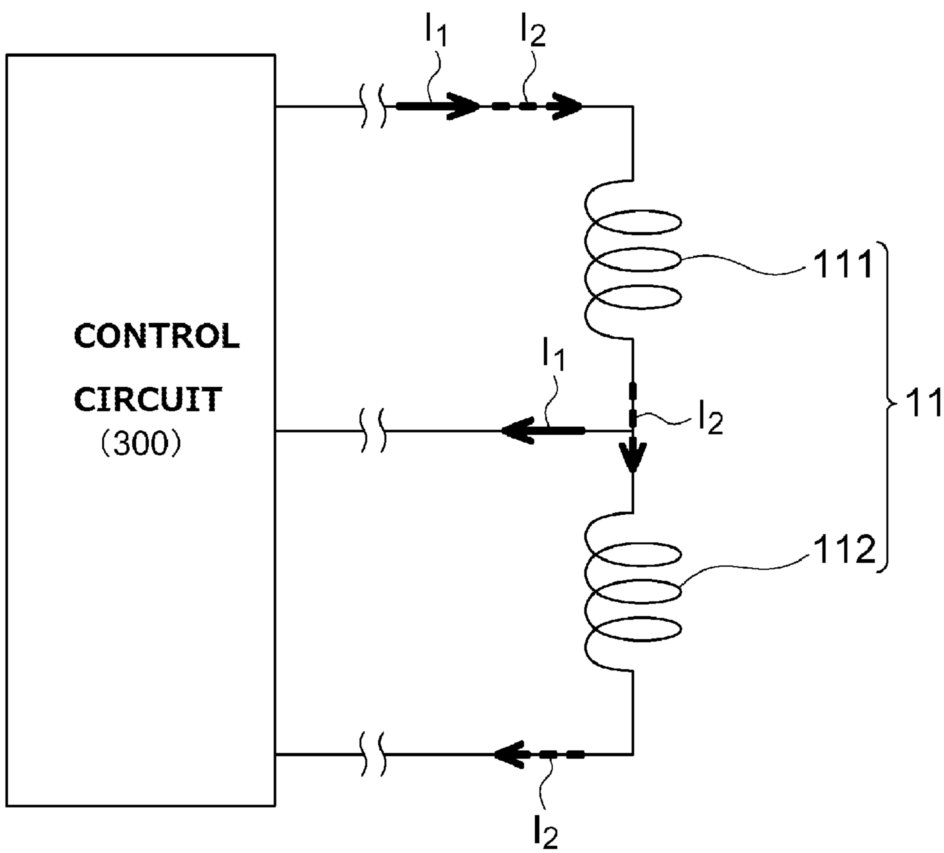

FIG. 5

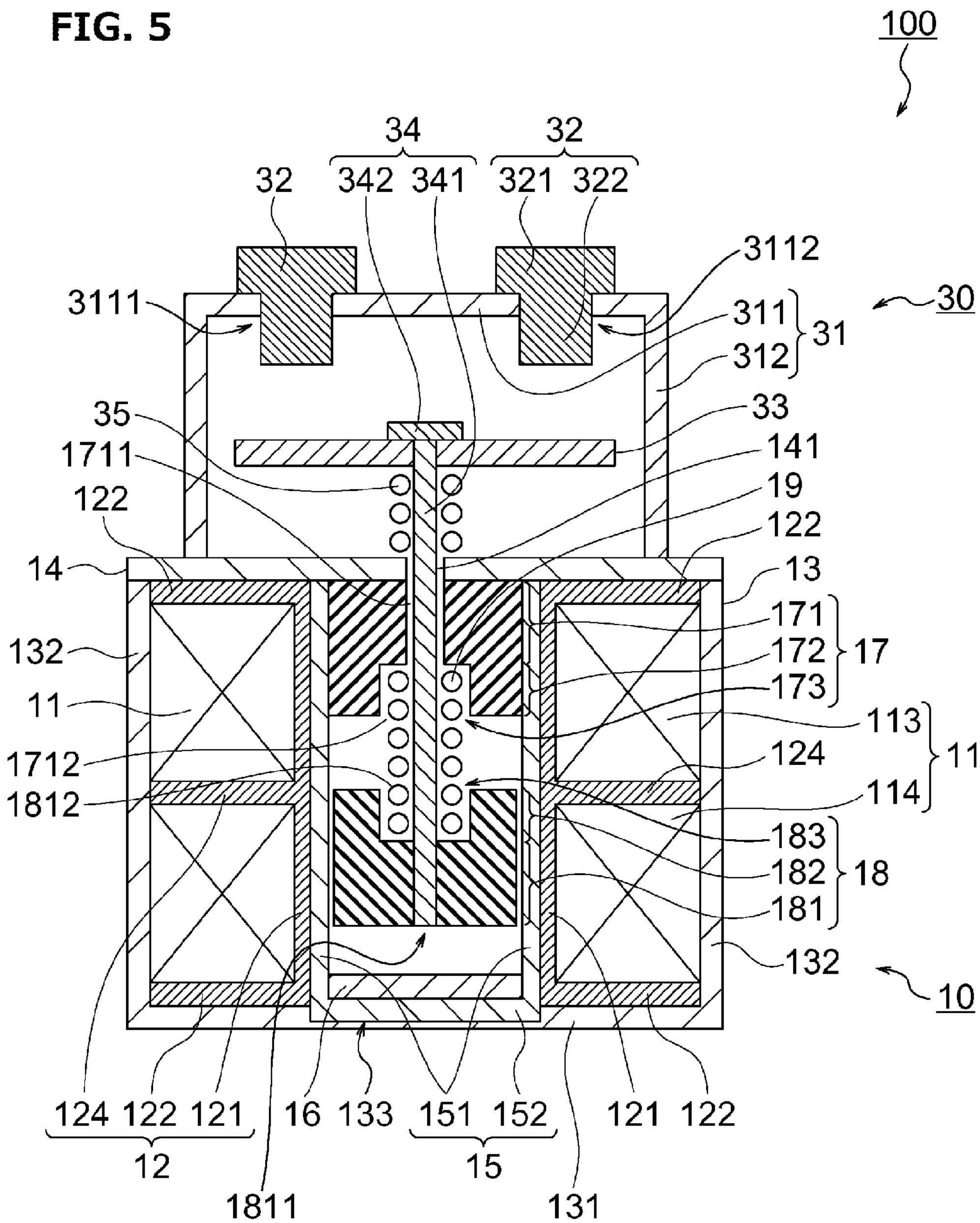
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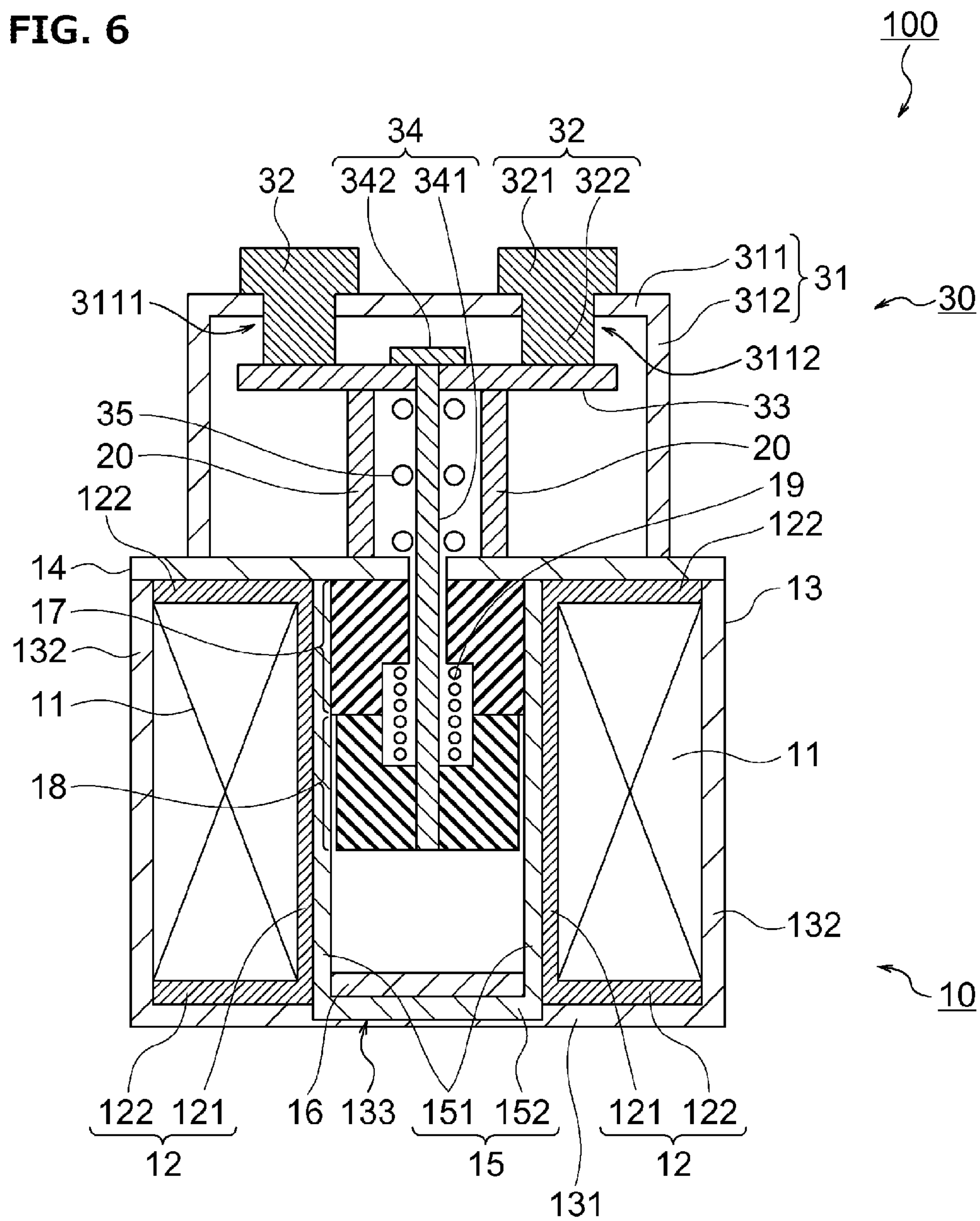
FIG. 6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ELECTROMAGNETIC RELAY

CROSS REFERENCE TO RELATED APPLICATION

The present application claims priority to Japanese Patent Application No. 2011-136151 filed on Jun. 20, 2011, which is incorporated herein in its entirety.

TECHNICAL FIELD

The present invention relates to an electromagnetic relay.

BACKGROUND

A starter solenoid switch such as that in JP Patent Publication No. 2004-207134 is provided with a plunger that is inserted into the inner diameter side of an exciting coil and opposes a fixed core with an air gap, a spring biasing the plunger in an anti-core direction, a fixed contact movable integrally with the plunger and, when sucked to the fixed core side upon energizing the exciting coil, comes into contact with the fixed contact to close a current supply circuit, and an elastic member mounted in the plunger to protrude toward a stopper surface side from an end surface of the plunger located on the anti-core side. When the plunger is sucked in the fixed core side and, due to disappearance of magnetic force, subsequently pushed back in the anti-core direction, since the elastic member abuts against the stopper surface, collision between the stopper surface and the counter-core end face of the plunger is avoided.

However, there is a problem that the collision energy generated between the fixed contact is large when the movable contact comes into contact with the fixed contact.

BRIEF SUMMARY

The problem which the present invention addresses is to provide an electromagnetic relay that can suppress the collision energy generated between the fixed contact and the movable contact.

The present invention solves the problem described above by providing a drive means that generates a first driving force for causing the movable contact to contact the fixed contact and a second driving force greater than the first driving force for holding the contact state.

According to the present invention, when the movable contact and the fixed contact are brought into contact, the contact pressure between fixed contact and the movable contact is reduced, and after the fixed contact and the movable contact has been contacted, the contact the pressure is increased. Therefore, it is possible to suppress the collision energy generated between the fixed contact and the movable contact.

BRIEF DESCRIPTION OF THE DRAWINGS

The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout the several views, and wherein:

FIG. **1** is a block diagram showing a battery pack including a relay switch pertaining to an embodiment according to the present invention;

FIG. **2** is a cross-sectional view of the relay switch in FIG. **1**;

FIG. **3** is a cross-sectional view of the relay switch pertaining to another embodiment according to the present invention;

FIG. **4** Is an equivalent circuit of the coil and the control circuit shown in FIG. **3**;

FIG. **5** is a cross-sectional view of the relay switch pertaining still another embodiment according to the present invention; and

FIG. **6** is a cross-sectional view of the relay switch pertaining to yet another embodiment according to the present invention.

DETAILED DESCRIPTION

Hereinafter, description is given of an embodiment according to the present invention with reference to the drawings.

FIG. **1** is a block diagram illustrating a battery pack of a vehicle including an electromagnetic relay (hereinafter referred to as a relay switch) in an exemplary embodiment according to the present invention. For example, the relay switch **100** is used as a main relay for electric vehicles or hybrid vehicles. The relay switch **10** may be applied to other switches for the vehicle or even be applied to a switch used as ones for the purpose other than vehicle.

As shown in FIG. **1**, the battery pack **200** includes a battery **201**, a relay switch **100**, a connector portion **202**, and fuses **203***a*~**203***d*. The battery **201** a drive source for driving the vehicle and is formed by connecting batteries such as secondary batteries or the like in series or in parallel. A relay switch **100** is respectively connected to a power supply line of the positive electrode side and the power supply line of the negative electrode side. Both the positive electrode side power supply line and the negative electrode side power supply line are connected to an inverter via a terminal **202**. Both fuses **203***a*, **203***c* are connected to the positive electrode side power supply line, while both fuses **203***b* and fuse **203***d* are connected to the negative side power supply line. The battery **201** is connected with a DC/DC converter via the relay switch **100**, the fuses **203***a*, **203***b*, while connected with an air conditioner (A/C) via the relay switch **100**, the fuse **203***c* and the fuse **203***d*.

Now, a specific configuration of the relay switch **100** will be described with reference to FIG. **2**. FIG. **2** is a cross-sectional view of the relay switch **100**. As shown in FIG. **2**, the relay switch **100** is provided with a driver portion **10** and a contact portion **30**.

The driver portion **10** is provided with a coil **11**, a bobbin **12**, a housing portion **13**, a top plate **14**, a plunger cap **15**, a rubber damper **16**, a fixed iron core **17**, a movable iron core **18**, and a return spring **19**. As will be described later, by driving the shaft **34** in the axial direction (vertical direction in FIG. **2**), the drive unit **10** functions as a member to cause the movable contact **33** and the fixed contact **32** to selectively contact with and separate from each other.

The coil **11** is formed in a cylindrical shape by winding a plurality turns of coil and generates a magnetic flux upon a current being supplied. The bobbin **12** is a member for holding the coil **11** and provided with a cylindrical wall portion **121** and a pair of plate portions **122** extending outwardly and vertically from both ends of the cylindrical wall portion **121**. The coil **11** is sandwiched by the pair of the plate portions **122**, **122**. The coil **11** is coupled to a control circuit (not shown) and generates a magnetic flux outputted from the control circuit.

The housing portion **13** is formed into a bottomed cylindrical shape, and provided with a bottom portion **131** and a wall portion **132** extending in the vertical direction of the bottom surface **131** with the direction facing the bottom surface portion **131** open.

Further, the central portion of the bottom portion **131** is provided with a recess **133**. The housing portion **13** is formed of a magnetic material of a metal such as iron. The top plate **14** is formed in a cylindrical shape. The central portion of the upper plate portion **14** is formed with a through hole **141** for passing a shaft which will be described later. The upper plate **14** is formed of magnetic material and serves as a lid portion of the housing portion **13** to cover the opening of the housing portion **13** from the direction opposed to the bottom surface portion **131**, and fixed to the side wall **132** by caulking and the like.

The plunger cap **15** is formed into a bottomed cylindrical shape and includes a cylindrical portion **151** of cylindrical shape and a bottom portion **152** that covers the bottom surface of the cylindrical portion **151**. The plunger cap **15** is press-fitted into the hollow portion covered with the wall portion **121** of the bobbin **12** and the recess **133** to be assembled to cover the recess **133** and the inside of the wall portion **121**. Thus, the coil **11** and the bobbin **12** are accommodated by the housing portion **12**, upper plate **14** and the plunger cap **15**. Further, a rubber dumper **16** is provided on the upper surface of the bottom portion **152** of the plunger cap **15**, and the rubber dumper **16** is formed of elastic member in a cylindrical shape. The rubber dumper **16** is provided to absorb the collision energy between the movable iron core **18** and the plunger cap **15**.

The fixed core **17** is formed by a cylindrical portion **171** integrally with a cylindrical portion **172** with the same outer periphery of the cylindrical portion **171**. The cylindrical portion **171** and the cylindrical portion **172** are disposed coaxially, each being provided with an insertion hole **1711**, **1721** in each axis for inserting a shaft **34** to be described later. The outer wall surface of the cylindrical portion **171** and the outer wall surface of the cylindrical portion **172** are formed so as to be flush with each other, and the diameter of the insertion hole **1712** is formed to be larger than the diameter of the insertion hole **1711**. Thus, the fixed core **17** is formed with a recess **173** which is recessed toward the upper side from the bottom surface of the cylindrical portion **172**. For example, the fixed iron core **17** is formed by laminating steel plates of a metal such as iron. The fixed core **17** is press-fitted into the inside of the cylindrical portion **152** of the plunger cap **15** and is in close contact with the top of the plunger cap **15**. Further, the diameter of the insertion hole **1711** is formed to be larger than the diameter of the axial portion **341** of the shaft **34** so that a gap is formed between the inner surface of the cylindrical portion **171** and the surface of the axial portion **341** of the shaft **34**. Thus, the inner surface of the cylindrical portion **171** serves as a sliding surface for sliding the shaft **34**.

The movable core **18** is formed by a cylindrical portion **181** integrally with a cylindrical portion **182** with the same outer periphery of the cylindrical portion **181**. The cylindrical portion **181** and the cylindrical portion **182** are disposed coaxially, each being provided with an insertion hole **1811**, **1812** in each axis for inserting a shaft **34** to be described later. The outer wall surface of the cylindrical portion **181** and the outer wall surface of the cylindrical portion **182** are formed so as to be flush with each other, and the diameter of the insertion hole **1812** is formed to be larger than the diameter of the insertion hole **1811**. Thus, the movable core **18** is formed with a recess **183** which is recessed toward the lower side from the upper surface of the cylindrical portion **183**. For example, the movable iron core **18** is formed by laminating steel plates of a metal such as iron. The movable core **18** is inserted into a cylindrical portion **152** of the plunger cap **15**. Further, the diameter of the outer periphery of the movable core **18** is formed to be smaller than a diameter of a driving portion of the cylindrical portion **152**. A gap is formed between the outer surface of the movable core **18** and the inner surface at the lower portion of the cylindrical portion **152**. Further, the tip portion of the shaft **34** is press-fitted into an insertion hole **1811** of the cylindrical portion **181** so that the tip portion of the shaft **34** and the cylindrical portion **181** are fixed to each other. Thus, the outer surface of the movable core **18** serves as a sliding surface with respect to the inner surface of the plunger cap **15**. The magnetic circuit is formed by the housing **13**, the upper plate **14**, the fixed iron core **17** and the movable iron core **18**.

A return spring **19** is an elastic member of a coil shape having an inner diameter greater than the outer diameter of the shaft portion **341** of the shaft **34** provided coaxially with the central axis of the shaft portion **341**. The shaft **34** is inserted into a cavity part of the return spring. By fitting the upper end portion of the return spring **19** into the recess **173** and the lower end portion of the return spring **19** into the recess **183**, respectively, the return spring is respectively fixed to both the movable iron core **18** and the fixed core **17**. The return spring **19** urges the movable core **18** in a direction which deviates movable contact **33** from the fixed contact **32**.

A contact portion **30** includes a base block **31**, a pair of fixed contacts **32**, a movable contact **33**, a shaft **34**, and a contact pressure spring **35**.

The base block **31** is formed in an insulating member of rectangular shape, and provided with a top plate **311** and a wall portion **312** extending vertically from the end of the top plate **311** with the direction facing the top plate **311** open. The top plate **311** is formed with insertion holes **3111**, **3112** for insertion of the pair of the fixed contacts **32**. The lower end of the wall portion **312** is fixed to the upper plate **14**. Further, the movable contact **33** and the upper portion of the shaft **34** are accommodated within a space defined by the top plate **311**, the wall portion **312**, and the upper plate **14**.

The fixed contact **32** is formed of a conductive material such as copper, for example, and formed by a cylindrical portion **321** and a cylindrical portion **322** integral with the cylindrical portion **321** having the outer periphery smaller than the outer periphery of the cylindrical portion **321**. The outer periphery of the cylindrical portion **322** is formed slightly larger than the insertion holes **4111**, **3112** provided in the top plate **311**. With respect to the fixed contact **32**, the lower cylindrical portion **322** is inserted in the insertion holes **3111**, **3112** of the top plate **311** while the cylindrical portion **321** is fixed to the base block **31** with the cylindrical portion **321** projecting outwardly from the base block **31**. The base surface of the cylindrical portion **322** serves a contact portion with the surface of the movable terminal **13**.

The movable contact **33** is formed of a conductive material such as copper of a plate shape, for example. An insertion hole is provided at the center of the movable contact **33** for inserting the shaft **34**. By inserting the shaft **34** into the insertion hole, the movable contact **33** is fixed to the shaft **34**. The upper surface of the movable contact **33** provides a contact with the fixed contact **32**.

The shaft **34** is formed by a non-magnetic material and includes a rod-shaped shaft portion **341** and a bearing portion **342** provided at one end of the shaft portion **341**. The shaft portion **341** is inserted in the insertion hole at the center of the movable contact **33** and into the insertion holes **1811**, **1812** at the center of the movable core **18** so as to be fixed to both the movable contact **33** and the movable core **18**. Further, the shaft portion **341** is movably inserted in the inner cavity portion of the movable contact **33**, the insertion hole **141** at the center of the upper plate **14**, the insertion holes **1711**, **1712** at the center of the fixed core **17**, and the inner cavity portion of the return spring **19**. The bearing portion **342** is formed with its outer diameter larger than the diameter of the insertion hole of the movable contact **33** and fixed to the movable **33**. The shaft **34** is movable in the axial direction of the central axis of the shaft portion **341** (in the vertical direction in FIG. **2**) in response to the ON and OFF operation of the relay switch **100** so that the axial direction of that central axis represents a moving direction of the movable contact **33** and the movable core **18**.

The contact pressure spring **35** is an elastic member of coil having an inner diameter greater than the outer diameter of the shaft portion **341** of the shaft **34** provided coaxially with the central axis of the shaft portion **341**. The contact pressure spring **35** is disposed between the movable contact **33** and the upper plate **14**. The contact pressure spring **35** biases the movable contact **33** in a direction of contact of the movable contact with the fixed contact **32**.

Now, description will be given of the operation of the relay switch **100** with reference to FIG. **2**. In a state where no current is applied to the coil **11**, the fixed contact **32** and the movable contact **33** are opposed with a gap in between. First, from the state in which the fixed contact **32** and the movable contact **33** are separated from each other, a contact current (I**1**) is supplied to the coil **11**. The contact current (I**1**) is the minimum current that is allowed to drive the shaft **34** is set to establish at least a partial contact between the movable contact **33** and fixed contact **32**. The contact current (I**1**) is lower than a holding current (I**2**) described below and does not present a sufficient current value to continuously hold the ON state of the relay switch **100**.

When contact current (I**1**) flows and the coil **11** is energized, the movable iron core **18** is attracted to the fixed core **17** and the shaft **34** fixed to the movable iron core **18** is driven in the axial direction of the shaft portion **341** to cause the movable contact **33** to contact the fixed contact **32**. Then, after a control circuit (not shown) connected to the coil **11** has confirmed the continuity of the coil **11** by detecting a voltage or the like of the wiring between the coil **11** and the control circuit, the holding current (I**2**) is caused to flow. Note that the holding current (I**2**) is a previously set current to hold the contact state between the fixed contact **32** and the movable contact **33**. The holding current (I**2**) is a current higher than the contact current (I**1**), and by strengthening the contact between the fixed contact **32** and the movable contact **33** to continuously hold the ON state of the relay switch. When the holding current (I**2**) flows through the coil **11**, since the contact pressure between the fixed contact **33** and movable contact **33** becomes large compared to the contact pressure when the contact current (I**1**) passes through the coil **11**. Thus after the movable contact **33** has contacted the fixed contact **32**, the holding force of the movable contact **33** and fixed contact **32** is increased.

Specifically, in the present embodiment, when turning on the relay switch **100**, the contact current (I**1**) is flown in the coil **11** and impart a small driving force (P**1**) to the shaft **34** to bring the fixed contact **32** into contact with the moving contact **33** while holding the contact pressure between the fixed contact **32** and the movable contact **33** small. When turning on the relay switch **100**, the vehicle is stopped so that the vibrations exerted on the relay switch **100** is small. Thus, it suffices when the fixed contact **32** and the movable contact **33** are in contact with each other, and no large driving force is required. Thus, in the present embodiment, when turning on the relay switch **100**, the movable contact **32** is driven under a small driving force.

Then, after the fixed contact **32** and the movable contact **33** have come into contact with each other, the coil **11** is supplied with the holding current (I**2**) so that, by adding a large driving force (P**2**) larger that the driving force (P**1**) to the shaft **34**, the contact state between the fixed contact **32** and the movable contact **33** is held while maintaining the contact pressure large between the fixed contact **32** and the movable contact **33**. After the fixed contact **32** and the movable contact **33** have been brought into contact, it is possible that a large vibration is added to the relay switch **100** when the vehicle starts to move. Thus, in order to prevent the fixed contact **32** from being separated from the movable contact **33**, a large driving force toward the shaft **34** is required. Thus, in the present embodiment, after the relay switch has been turned on, the moving contact **33** will be driven under a large driving force (P**2**).

On the other hand, when stopping the energization of the coil **11**, the movable contact **33** is deviated from the fixed contact **32** from the state in which the movable contact **33** and fixed contact **32** are in contact by the return spring **19**, so that the relay switch **100** become off.

As described above, in the present embodiment, by setting a current to be supplied to the coil **11** so as to allow to magnetize the fixed core **17** and the movable core **18** to drive the shaft **34** so that the movable contact **33** will come into contact with the fixed contact **32**. In order to turn the relay switch on, when driving the movable contact **33**, the movable contact **33** and the fixed contact **32** are caused with contact each other by the driving force (P**1**) while the movable contact **33** and the fixed contact **32** are held in contact condition by the driving force (P**2**). Thus, when the movable contact **33** and the fixed contact **32** are brought into contact each other, the contact pressure will be small between the movable contact **33** and the fixed contact **32**. After the movable contact **33** and the fixed contact **32** have been brought into contact, the contact pressure will be caused to be increased. Thus, when turning on the relay switch **100**, it is possible to suppress the collision energy generated between the movable contact **33** and fixed contact **32**.

Incidentally, unlike the present embodiment, in order to contact the fixed contact **32** and movable contact **33** from the state in which the fixed contact **32** and movable contact **33** are deviated, when the movable contact **33** is allowed to be driven by driving the shaft under a large force, at both the contact point between the movable contact **33** and the fixed contact **22** and the movable core **18** and the fixed core **17**, during the collision, in some cased a large noise is generated or the life of the contact portion or shortened.

Further, in the case of providing an elastic body between the movable contact and the fixed contact **32**, because the elastic modulus of the elastic body changes depending on ambient temperature and external deterioration of the elastic body, it is likely impossible to reduce the collision energy.

On the other hand, in the present embodiment, when turning on the relay switch **100**, the movable contact **33** and the fixed contact **32** are brought into contact under the driving force (P**1**), and the contacted condition between the movable contact **33** and the fixed contact **32** is held by the driving force (P**2**). Therefore, at both the contact point between the movable contact **33** and the fixed contact **22** and the movable core **18** and the fixed core **17**, during the collision energy is reduced to prevent noise at the contact portion with wear being suppressed as well.

Further, after the fixed contact **32** is in contact with the movable contact **33**, to hold the contact between the fixed contact **32** and movable contact **33** driving force (P**2**) is applied. Thus, for example, it is possible to prevent the contact portions to separate due to the vibration or shock that are received while the vehicle is running. As a result, it is possible to prevent such situation from occurring in which the increase in the contact portion or adhesion of the contacts is encountered associated with separation of the contact portions.

Also, in the present embodiment, by causing the contact current (I**1**) to flow in the coil **11**, the driving force (P**1**) is generated, while by allowing the holding current (I**2**) to flow in the coil **11**, the driving force (P**2**) is produced. Thus, by changing the current value to be supplied to the coil **11**, the driving force (P**1**) and the driving force (P**2**) are subject to selective production, at least one coil is needed to be provided so that it is possible to suppress the cost of the relay switch **100**.

Note that the structure comprising at least a coil **11** and pertaining to a fixed core **17** and a movable core **18** corresponds to the "driving means" according to the present invention. The coil **11** corresponds to the "electromagnetic coil", the driving force (P**1**) to the "first driving force", the driving force (P**2**) to "the second driving force", the contact current (I**1**) to "the first current", and the holding current (I**2**) to "the second current", respectively.

FIG. **3** is a cross-sectional view of the relay switch **100** according to another embodiment of the present invention. Compared to the first embodiment described above, the configuration in the second embodiment is different in both the coil **11** and the bobbin **12**. Since the structure other than these is the same as the first embodiment, the description thereof will be incorporated the description, when appropriate.

As shown in FIG. **3**, the coil **11** is provided with a coil **111** and a coil **112**. The coil **111** and the coil **112** are disposed so that each axis is aligned with the axis of the shaft portion **341** of the shaft **34**. The coil **111** is disposed inside the coil **112** and is sandwiched between the wall portion **121** and the wall portion **123**. The coil **112** is sandwiched between the wall portion **123** and the wall portion **132** of the cylindrical portion **13**. Each length of the coil **111** and the coil **112** are formed to be equal in the axial length of the coil **111** and the coil **112**.

The bobbin **12** includes a wall portion **121**, a pair of plate portion **122**, and a wall portion **123**. Between the pair of wall portions **123**, the wall portion **123** is disposed so as to be parallel to the wall portion **121**. Between the wall portion **121** and wall portion **123**, a space is provided to accommodate the coil **111**, while between the wall portion **123** and the wall portion **132**, a space for receiving the coil **112** is provided.

Now, description is given of the operation of the relay switch **100** with reference to FIGS. **3** and **4**. FIG. **4** shows an equivalent circuit of the coil **11** and the control circuit **300**, illustrating a series circuit of the coil **111** and coil **112**. In a state where the movable contact **33** and fixed contact **32** are separated, a contact current (I**1**) is supplied to the coil **111**, whereas the contact current (I**1**) will not be supplied to the coil **112**. The contact current (I**1**) is a minimal current that, when allowed to pass the coil **111**, drives the shaft **34** to cause at least portion between the fixed contact **32** and the movable contact **33** to contact.

When the coil **11** is supplied with the contact current (I**1**), although the coil **112** will not be magnetized, the coil **111** is magnetized to produce a small force (P**1**) to the shaft **34** and the movable core **18** is attracted to the fixed core **17** to move the shaft **34** in the axial direction to thereby allow the movable contact **33** to contact the fixed contact **32**. Then, by detecting by the control circuit **300** connected to both the coil **111** and the coil **112** the current or the like between the coil **111** and the control circuit **300**, the continuity of the coil **111** is confirmed. Thereafter, the holding current (I**2**) will be supplied to the coil **111** and the coil **112**. Note that the holding current (I**2**) is a previously set current to hold or maintain the contact condition between the fixed contact **32** and the movable contact **33**, and, by further strengthening the contact or attracting between the fixed contact **32** and the movable contact **33**, the ON state of the relay switch **100** will be maintained on the continuous basis. The magnitude of the holding current (I**2**) may be the same as the contact current (I**1**).

Since, when the holding current (I**2**) flows through the coil **111** and coil **112**, both the coil **111** and coil **112** are energized, as compared with the case where the contact current (I**1**) flows coil **111** only, the magnetic flux applied which acts with the magnetic circuit of the relay switch **100** will be stronger. Thus, a large driving force (P**2**) are generated in the shaft **34**, the contact pressure between the movable contact **33** and the fixed contact **32** will be larger as compared to the case where the contact current (I**1**) is supplied to the coil **111** only. Therefore, after the contact of the movable contact **33** with the fixed contact **32**, the holding force between the fixed contact **32** and the movable contact **33** will be increased.

As described above, in the present embodiment, the coil **11** is composed of a plurality of coils **111** and **112**. By supplying the coil **111** with the contact current (I**1**) to thereby energize the coil **111**, a driving force (P**1**) is generated, while by supplying a holding current (I**2**) both the coil **111** and the coil **112** to thereby energize both coils **111**, **112**, a driving force (P**2**) will be generated. Thus, the driving force is not necessarily be changed by controlling the current value to thereby change the driving force of the shaft **34**. Therefore, it is possible to prevent the circuit structure of the control circuit **300** from being complicated.

Further, in the present embodiment, the current to be supplied to the coil **11** may be set constant. Thus, without changing the current value, when turning the relay switch **100** on, the collision energy generated between the fixed contact **32** and movable contact **33** may be suppressed.

Further, in the present embodiment, the coil **112** is disposed outside of the coil **111** in such a way that the axis of the coil **111** and that of the coil **112** are aligned with the axis of the shaft **34**. Thus, it is possible to easily control the speed of the movable shaft **34** since the electromagnetic force may be applied within the movable range of the shaft **34**.

Further, in the present embodiment, the axial length of the coil **111** and that of the coil **112** are configured to be equal. Thus, it is possible to easily control the speed of the movable shaft **34** since the electromagnetic force may be applied within the movable range of the shaft **34**.

Note that, in the present embodiment, the shaft **134** may be imparted by the driving force (P**1**) through current supply to the outside coil **112**. Thus, since the coil **112** is located outside of the coil **111** and thus remote with respect to the magnetic circuit, to supply the same contact current (I**1**) to the coil **111**, the driving force may made smaller so that the conflict energy be suppressed.

Note that the coil **11** is not necessarily composed of two coils, but may be composed of three or more coils. Further, the axial length of the coil **111** and that of the coil **112** do not have to be the same.

The "shaft **34**" corresponds to the "movable shaft" according to the present invention and the coil **111** and coil **112** correspond to the "plurality of coils".

FIG. **5** is a cross-sectional view of the relay switch according to another embodiment of the present invention. Compared to the first embodiment described above, the configuration of the coil **11** and the bobbin **12** is different. The other configurations are the same as the first embodiment described above, which is incorporated according to the first and second embodiments when appropriate.

As shown in FIG. **5**, the coil **11** includes a coil **113** and a coil **114**. The coil **113** and the coil **114** are disposed so that each axis is aligned with the axis of the shaft portion **341** of the shaft **34**. The coil **113** is disposed on the upper side of the coil with respect to the axial direction of the axis, and is sandwiched between the upper plate portion **122** f the bobbin **12** and the plate portion **124**. The coil **114** is sandwiched between the plate portion **124** and the lower plate portion **122**. The coil **113** is disposed closer to the movable contact **33** than the coil **114** while the coil **114** is disposed farther from the movable contact **33** than the coil **113**.

The bobbin **12** includes a wall portion **121**, a pair of plate portions **122**, and a plate portion **124**. Between the pair of plate portions **122**, the plate portion **124** is disposed parallel to the plate portion **122**. Between the upper plate portion **122** and the plate portion **124** is provided a space for accommodating the coil **113**. Between the lower plate portion and the plate portion **124**, a space for receiving the coil **114** is provided.

Now, description is made of the operation of the relay switch **100** with reference to FIG. **5**. When a contact current (I**1**) is supplied to the coil **114** in a state whereas the fixed contact **32** and the movable contact **33** are separated while withholding to supply the contact current (I**1**) to the coil **113**. The contact current (I**1**) is a minimal current that, when allowed to pass the coil **111**, drives the shaft **34** to cause at least portion between the fixed contact **32** and the movable contact **33** to contact.

When the coil **114** is supplied with the contact current, although the coil **113** will not be magnetized, the coil **114** is magnetized to produce a small force (P**1**) to the shaft **34** and the movable core **18** is attracted to the fixed core **17** to move the shaft **34** in the axial direction to thereby allow the movable contact **33** to contact the fixed contact **32**. Then, by detecting by the control circuit **300** connected to both the coil **114** and the coil **113** the current or the like between the coil **114** and the control circuit **300**, the continuity of the coil **114** is confirmed. Thereafter, the holding current (I**2**) will be supplied to the coil **113** and the coil **114**. Note that the holding current (I**2**) is a previously set current to hold or maintain the contact condition between the fixed contact **32** and the movable contact **33**, and, by further strengthening the contact or attracting between the fixed contact **32** and the movable contact **33**, the ON state of the relay switch **100** will be maintained on the continuous basis. The magnitude of the holding current (I**2**) may be the same as the contact current (I**1**).

Since, when the holding current (I**2**) flows through the coil **113** and coil **114**, both the coil **113** and coil **114** are energized, as compared with the case where the contact current (I**1**) flows coil **114** only, the magnetic flux applied which acts with the magnetic circuit of the relay switch **100** will be stronger. Thus, a large driving force (P**2**) are generated in the shaft **34**, the contact pressure between the movable contact **33** and the fixed contact **32** will be larger as compared to the case where the contact current (I**1**) is supplied to the coil **114** only. Therefore, after the contact of the movable contact **33** with the fixed contact **32**, the holding force between the fixed contact **32** and the movable contact **33** will be increased.

As described above, in the present embodiment, the coil **113** and the coil **114** are disposed side by side in the axial direction with the axis of the coil **113** and that of the coil **114** aligned with the axis with the shaft **34**. Thus, it is possible to easily control the speed of the movable shaft **34** since the electromagnetic force may be applied within the movable range of the shaft **34**.

Note that, in the present embodiment, by supplying current to the upper side coil **113** in the axial direction, the driving force (P**1**) is generated to obtain the same effect.

The coil **113** and the coil **114** correspond to the "plurality of coils" according to the present invention.

FIG. **6** is a cross-sectional view of the relay switch according to yet another embodiment of the present invention. The point in difference from the first embodiment described above resides in that the driving force (P**2**) is generated by n actuator **20**. Other configurations than this is the same as the first embodiment so that the descriptions in the first to third embodiments may incorporated when appropriate. Note that FIG. **6** shows a cross-sectional diagram in the state where the fixed contact **32** and the movable contact **33** are in contact with each other.

As shown in FIG. **6**, the drive unit **10** includes an actuator **20**. The actuator is provided in the space formed by the top plate **311**, the wall portion **312** and the upper plate **14**, and is disposed between the movable contact **33** and top plate **14**. The actuator **20** serves as a pressing member to pressurize the movable contact **33** in the axial direction of the shaft **34**. The actuator **20** is formed in a cylindrical shape so as to cover the shaft **34** and the contact pressure spring **35** with a predetermined interval. The actuator **20** is configured to expand or contract in the axial direction of the shaft to generate a stress in the axial direction of the shaft **34**.

The actuator is connected to a control circuit (not shown) for controlling the relay switch of the present embodiment, and is driven by a signal from the control circuit to push up the movable contact **33** toward the fixed contact **32**. The driving force (P**2**) to the movable contact **33** and the shaft **34** by the actuator **20** is a larger force that the driving force (P**1**) that generates in response to the contact current (I**1**) being supplied to the coil **11**.

In the off-state of the relay actuator **200** opposing the movable contact **33** switch, i.e., in the state where the fixed contact **32** and the movable contact **33** are free from contact, the actuator **20** does not produce the driving force (P**2**), the top end of the actuator **20** opposing the movable contact **33** lowers in the axial direction of the shaft **34** so as to approach the top plate **14**. Thus, the movable contact will be separated from the fixed contact **32**.

Now, description will be given of the operation of the relay switch **100**. In a state where no current is supplied to the coil **11**, the fixed contact **32** and the movable contact **33** are opposed with a gap in between. First, in the state in which the fixed contact **32** and the movable contact **33** are separated from each other, a contact current (I**1**) is supplied to the coil **11**. The contact current (I**1**) is the minimum current that is allowed to drive the shaft **34** is set to establish at least a partial contact between the movable contact **33** and fixed contact **32**. The contact current (I**1**) does not present a sufficient current value to continuously hold the ON state of the relay switch **100**.

When the contact current (I**1**) is caused to flow in the coil **11**, the coil **11** is energized and the driving force (P**1**) is generated. The movable iron core **18** is attracted to the fixed core **17** and is fixed to the movable iron core **18**. At this point, the actuator **20** is not generating a stress.

Then, after a control circuit (not shown) connected to the coil **11** has confirmed the continuity of the coil **11** by detecting a voltage or the like of the wiring between the coil **11** and the control circuit, the control circuit causes the actuator **20** to be driven. The actuator **20** generates a driving force (P**2**) to strengthen the attracting force between the fixed contact **33** and the movable contact **33** to maintain the ON-state **100**.

When the actuator **20** is driven, the contact pressure between the movable contact **33** and the fixed contact **32** is set larger compared to the contact pressure at the time where the contact current (I**1**) is supplied to the coil **11** to drive the movable contact **33** by the driving force (P**1**) only. Thus, after the movable contact **33** has contacted the fixed contact **32**, the holding force of the fixed contact **32** and the movable contact **33** will be larger.

As described above, in the present embodiment, by setting the current to be supplied to the coil **11** and energize both the fixed core **17** and the movable core **18**, to thereby drive the movable contact **33** so as for the movable contact **33** to come to contact with the fixed contact **32**, the movable contact **33** and the fixed contact **32** are brought into contact by the driving force (P**1**). Further, by the driving force (P**2**) of the actuator **20**, the contact state of the movable contact **33** and the fixed contact **32** is maintained. Thus, when the movable contact **33** and the fixed contact **32** come into contact, the contact pressure between the movable contact **33** and the fixed contact **32** is small, whereas, after contact between the movable contact **33** and the fixed contact **32**, the contact pressure is allowed to be increased. Therefore, when turning on the relay switch **100**, the impact energy generated between the movable contact **33** and the fixed contact **32** may be suppressed.

Further, after the fixed contact **32** is in contact with the movable contact **33**, since the contact between the fixed contact **32** and movable contact **33** is held by the driving force (P**2**), for example, it is possible to prevent the contact portions to separate due to the vibration or shock that is received while the vehicle is running. As a result, it is possible to prevent temperature rise of the contact portions or adhesion of the contacts due to occurrence of separation of the contact portions.

Note that in the present embodiment, the actuator may be formed in a mechanism driven by hydraulic pressure, a mechanism driven by an air pressure, or a mechanism that is driven by a mechanism driven by an internal motor. The actuator **20** described above corresponds to the "drive means" according to the present invention.

The invention claimed is:

1. An electromagnetic relay, comprising:

a fixed contact;

a movable contact for selectively contacting with or separating from the fixed contact; and

a drive unit having at least an electromagnetic coil unit having a plurality of coils for driving the movable contact so as to come into contact with the fixed contact,

wherein the drive unit is configured to generate a first driving force to cause the movable contact to contact the fixed contact and a second driving force greater than the first driving force to hold a contact state between the movable contact and the fixed contact, wherein after the movable contact and the fixed contact have contacted, the second driving force is caused to be generated from the first driving force, the first driving force generated by supplying current through a portion of the plurality of coils and the second driving force generated by supplying current to all of the plurality of coils.

2. The electromagnetic relay as claimed in claim **1**, further comprising:

a movable shaft for selectively contacting or separating the movable contact and the fixed contact, wherein the electromagnetic coil unit has an axis aligned with an axis position of the movable shaft; and

one coil of the plurality of coils is disposed inside of another coil of the plurality of coils.

3. The electromagnetic relay as claimed in claim **1**, further comprising:

a movable shaft for selectively contacting and separating the movable contact and the fixed contact, wherein the electromagnetic coil unit has an axis of the plurality of coils aligned with an axis of the movable shaft, and

the coils of the plurality of coils are disposed side by side in an axial direction.

4. An electromagnetic relay comprising:

a fixed contact;

a movable contact for contacting the fixed contact; and

a drive unit having at least an electromagnetic coil unit having a plurality of coils for driving the movable contact so as to come into contact with the fixed contact,

wherein the drive unit is configured to generate a first driving force to cause the movable contact to contact the fixed contact and a second driving force greater than the first driving force to hold a contact state between the movable contact and the fixed contact, wherein the drive unit is configured to generate the first driving force by supplying a first current to the electromagnetic coil and to generate the second drive force by supplying a second current greater than the first current, the first driving force generated by supplying current through a portion of the plurality of coils and the second driving force generated by supplying current to all of the plurality of coils.

5. An electromagnetic relay comprising:

a fixed contact;

a movable contact for contacting the fixed contact;

a drive unit having at least an electromagnetic coil unit having a plurality of coils for driving the movable contact so as to come into contact with the fixed contact; and

a movable shaft for selectively contacting and separating the movable contact and the fixed contact, an axis of the plurality of coils aligned with an axis of the movable shaft,

wherein the drive unit is configured to generate a first driving force to cause the movable contact to contact the fixed contact and a second driving force greater than the first driving force to hold a contact state between the movable contact and the fixed contact, wherein the drive unit is configured to generate the first driving force by supplying a first current to the electromagnetic coil and to generate the second drive force by supplying a second current greater than the first current, and wherein the coils of the plurality of coils are disposed side by side in an axial direction or one coil of the plurality of coils is disposed inside of another coil of the plurality of coils.

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